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13. ABSTRACT *(Maximum 200 Words)*

This report describes the equipment acquired with funds from grant F49620-97-1-0093, awarded by the Air Force Office of Scientific Research (AFOSR) through the 1997 Defense University Research Instrumentation Program (DURIP) to Dr. Brian Dyre, Assistant Professor of Psychology, University of Idaho. Part I describes the equipment acquired, special circumstances regarding the acquisition, changes to the equipment as listed in the original proposal, and justifications thereof. Part II summarizes the research projects, completed and ongoing, for which the equipment was used. As proposed, this program of research consists of basic psychophysical studies of the visual mechanisms underlying spatial orientation (the perception of our location in and movement through space) in the context of high workload and wide fields-of-view. Preliminary studies in this line of research have been conducted along two lines: a) perception of the speed of self-motion, or egospeed; and b) perception of the direction of self-motion, or heading. However, because the wide field-of-view display system became operational only recently, the research conducted to date, and summarized in this report, addressed issues requiring only a small field-of-view. The laboratory is expected to be fully functional by July 1998.

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Introduction

This report describes the equipment acquired with funds from grant F49620-97-1-0093, awarded by the Air Force Office of Scientific Research (AFOSR) through the 1997 Defense University Research Instrumentation Program (DURIP) to Dr. Brian Dyre, Assistant Professor of Psychology, University of Idaho. Part I describes the equipment acquired, special circumstances regarding the acquisition, changes to the equipment as listed in the original proposal, and justifications thereof. Part II summarizes the research projects, completed and ongoing, for which the equipment was used.

I. Equipment Acquired

Table 1 lists the names, manufacturers, and costs of the equipment acquired in descending order of cost.

Table 1. Equipment acquired with funds from AFOSR F49620-97-1-0093				
Item	*Manufacturer*	*Quantity*	*Unit Cost**	*Total Cost**
Hardware				
NEC GR-67 Rear Screen Projectors with Retro Enclosures	NEC Corporation	2	$21,207.00	$42,414.00
Complete Eye-Head Tracking system model 5000, Eyehead data integration System Model EH-SA, Upgrade to Multi-speed eye Camera Model 501HSU	Applied Science Laboratories (ASL)	1	$36,350.00	$36,350.00
HP C200 Visualize graphics workstation	Hewlett Packard Corporation	1	$33,269.73	$33,269.73
Kayak FX4 workstation with texture acceleration and internal Jaz Drive	Hewlett Packard Corporation	1	$12,075.00	$12,075.00
AMD 233MHz PC (MAG monitor returned for credit)	DirectWave	1	$1,959.67	$1,959.67
AMD 200MHz PC (MAG monitor returned for credit)	DirectWave	1	$1,829.67	$1,829.67
AMD 200MHz PC (MAG monitor returned for credit)	DirectWave	1	$1,829.67	$1,829.67
Removable Media for Iomega Jaz Drive	Iomega Corporation	16	$99.00	$1,584.00
Optiquest 17" Monitors (for AMD PCs)	Viewsonic	3	$503.16	$1,509.48
3000 VA Uninterrupible Power Supply	Deltec	1	$1,455.30	$1,455.30
21" High resolution Monitor	Viewsonic	1	$1,280.00	$1,280.00
EDAS AD/DA control/measurement unit	Intelligent Instrumentation	1	$1,124.55	$1,124.55
Cheetah Ultra wide SCSI 9.1GB hard disk	Seagate	1	$994.00	$994.00
Diamond Fire GL 1000 PRO	Diamond Multimedia	4	$197.99	$791.95
2nd Pentium Pro Processor	Intel	1	$733.00	$733.00
HR-S9400 Editing VCR	JVC	1	$662.00	$662.00
17" High Resolution (1600 x 1200) Monitor	Iayama	1	$559.00	$559.00
1000 VA Uninterrupible Power Supply	Deltec	1	$481.80	$481.80
Ethernet Hub: EE100TX 8-port SA (100 Mbit)	Intel	1	$458.00	$458.00
SVGA Splitter/Amplifier and Cables	WID Industries	2	$216.64	$433.27
Iomega External Jaz Drive 1GB	Iomega Corporation	1	$400.00	$400.00
color inkjet printer and spare cartridges	Epson	1	$400.00	$400.00
Writeable CD-ROM drive	Panasonic	1	$399.00	$399.00
1000 VA Uninterrupible Power Supply	Deltec	1	$383.90	$383.90
Scanjet 5P Color Flat Bed Scanner	Hewlett Packard Corporation	1	$334.00	$334.00
TV Superscan 2 NTSC video converter	ADS Technologies	1	$294.29	$294.29
700 VA Uninterrupible Power Supply	Deltec	1	$280.50	$280.50
Personal Digital Assistant: Palm Pilot	3Com	1	$247.78	$247.78
SVGA signal splitter/amplifier and extension cables	Wid Industries	1	$243.81	$243.81
SCSI expansion card	Iomega Corporation	4	$60.00	$240.00
32MB RAM Module	Micron	1	$236.40	$236.40

security cables	ACCO	8	$28.60	$228.80
TPG Unwinder Box (joystick interface for HP c200)	Technology Playgroup	1	$225.00	$225.00
350 VA Uninterrupible Power Supply	Deltec	1	$216.15	$216.15
16MB RAM module	Delkin Devices (manufactured by Compal)	1	$209.00	$209.00
Black Felt Curtains	Fabricland, Moscow, ID	1	$188.68	$188.68
Ultra wide SCSI controller	Adaptec	1	$185.00	$185.00
Misc. wiring, cables, lamps, fans, surge supressors for subject booth	various	1	$150.07	$150.07
32MB RAM Module	Micron	1	$148.00	$148.00
Fresnel Lense	Edmund Scientific	1	$139.30	$139.30
Video Projector "Breakout" Cables	Aatronics	2	$65.00	$130.00
Misc. Network and Communications Cables		1	$115.88	$115.88
Computer Input Device: NASCAR Pro racing wheel	Thrustmaster	1	$115.45	$115.45
Computer Input Device: RCS rudder control system	Thrustmaster	1	$108.92	$108.92
650MB OPT MEDIA REC CDR 25Pk #52097	Kodak	2	$51.35	$102.70
Computer Input Device: Sidewinder 3D Pro Joystick	Microsoft	2	$44.47	$88.93
16x internal CD-ROM drive	Toshiba	1	$84.99	$84.99
10MB Ether-9+ Hub		1	$77.19	$77.19
Network Interface Card (10baseT)	Linksys	2	$36.31	$72.61
Surge Suppressor		3	$18.89	$56.67
VGA extension cables male/female	WID Industries	2	$24.36	$48.71
PC tool kit	Belkin	1	$38.94	$38.94
HP video adapter for 9000C Visualize FX4	Hewlett Packard	1	$35.00	$35.00
Voltage Regulator Module for dual pentium pro	Intel	1	$32.00	$32.00
Snellen Eye Chart	Bernell	1	$13.50	$13.50
serial cable and gender changer		1	$8.38	$8.38
Software (not including that bundled with computer purchases)				
Sigmaplot v4.0	Jandel	3	$393.00	$1,179.00
Statistica	Statsoft	3	$195.95	$587.85
Canvas v5.0	Deneba	3	$160.00	$480.00
S-plus 4.0	Mathsoft	1	$419.95	$419.95
Visual C++ v5.0	Microsoft	5	$51.00	$255.00
Office Pro	Microsoft	3	$73.00	$219.00
Statistica Neural Net Software	Statsoft	1	$160.00	$160.00
MathCad v6.0	Mathsoft	1	$138.00	$138.00
Winzip	Niko Mac Computing	6	$22.00	$132.00
Windows 95 operating system	Microsoft	1	$56.00	$56.00
Desktop to Go for Palm Pilot	DataViz	1	$49.00	$49.00
Eudora Pro	Qualcomm	1	$44.00	$44.00
Viruscan Win NT	McCafee Software	1	$29.95	$29.95
Hardware bought with cost-sharing funds from the University of Idaho				
GLyder MP Video card (dual Glint TX, Glint Delta, 40MB RAM)	Symmetric	1	$3,520.00	$3,520.00
Pentium Pro computer	Micron	1	$3,450.86	$3,450.86

*Figures do not include all shipping costs and therefore may not exactly reflect those in the fiscal report

Special Circumstances

Two purchases involved special circumstances.

1) Three MAG Innovision monitors included with the three AMD PCs from DirectWave were faulty and returned for credit. These monitors were replaced with Viewsonic Optiquest monitors.
2) Two Microsoft Sidewinder Precision Pro Joysticks were found to be incompatible with the display systems. These were returned and exchanged for two Microsoft Sidewinder 3D Pro joysticks.

Changes to the Equipment List

The equipment purchased deviated from the equipment originally specified in the proposal in the following manner.

1) NEC GR-67 (Cathode Ray Tube or CRT) projectors replaced the Electrohome Digital Light Processing (DLP) projectors listed in the original proposal. According to literature published by Texas Instruments (TI), the developer of DLP technology, I expected that SXGA resolution (1280x1024) DLP displays would be available during the award period. However, TI did not bring this technology to market as planned and I felt the available 800x600 resolution was not sufficient for the laboratory. CRT projectors were the only technology available that met the resolution, brightness, and phosphor decay specifications needed. NEC submitted the most competitive bid for these projectors fit into rear projection display units.
2) The original proposal specified the Applied Science Laboratories (ASL) Model 4000 eye-head tracking and measurement system. By the time funds were awarded, ASL had developed the Model 5000 system, which exceeded the measurement capabilities of the Model 4000 at a reduced cost. Hence, I purchased the Model 5000 system rather than the less-capable and more expensive Model 4000.
3) Funds saved in the purchase of the display projectors and eye-head tracking system were used to purchase two graphics workstations for generating 3D experimental displays: 1) a Hewlett-Packard 800 series C200 Visualize Graphics Workstation, and 2) a Hewlett-Packard Kayak Visualize Graphics Workstation. These computers were purchased in place of the 2nd Micron Millennia Pro Plus System and Symmetric GLyder 3D Graphics Accelerator specified in the original budget. Preliminary experiments demonstrated that more computational power was necessary to create realistic experimental displays. This result, combined with vast improvements in 3D graphics technology during the time between submission of the proposal and the awarding of funds, caused a reconsideration of the display system purchase. The HP 800 series workstation provides superior 2-channel capability and is used to drive the 2 NEC projectors for our wide field-of-view experiments. It is integrated with the ASL eye-head tracking system. The HP Kayak workstation is set up in a separate room and drives a 21" monitor. It serves two purposes: 1) display generation/data collection for experiments requiring only small fields of view, and 2) display development for the wide-field system. As a result, we now have the capability to simultaneously collect data on two research projects, one using the large field-of-view system and one using the small field-of-view system.
4) To integrate the HP 800 series workstation with input controllers and the ASL eye-head tracking system additional hardware was necessary. First, the Technology Playgroup Unwinder Box was purchased to interface the Microsoft Sidewinder 3D Pro joysticks and other control devices (Thrustmaster rudder pedals and steering wheel) with the HP 800 series workstation. To provide real-time communication between the eye-head tracker, the display computer, and the file server an EDAS AD/DA unit (manufactured by Intelligent Instrumentation), and a local network consisting of two ethernet hubs (10MB and 100MB) was also purchased.
5) The Pentium Pro Micron Millennia system purchased with University of Idaho cost-sharing funds was upgraded with a second Pentium Pro processor, additional RAM, and a Seagate 9GB Ultra-wide SCSI disk and converted to a file server for the HP 800 series graphics workstation and ASL eye-head tracking system. Our experiments generate an enormous quantity of time-series data (both performance data and eye-head tracking data). A large, independent storage system is necessary to allow continuous access to data and display programs without disruption of experimental displays. A networked multiprocessor file server provides this capability by allowing continuous network access to data and programs without "stealing" CPU cycles from computers used to generate displays during experiments and therefore disrupting data collection.

The funds saved in the projector and eye-tracker purchases were also used to obtain other equipment not specified in the original proposal. To create a laboratory in which projects could be planned, data collected, results analyzed, and papers and presentations prepared as efficiently as possible, the following equipment was deemed necessary:

1) Three AMD-K6 processor PCs (manufactured by DirectWave) upgraded with Diamond Fire GL 1000 Pro 3D accelerator cards (Diamond Multimedia) were purchased for 3D display development, analysis of data, and preparation of papers and presentations. Two additional RAM modules were purchased to upgrade pre-existing laboratory computers used for the same purposes. Software for system maintenance (Windows 95, Winzip, Viruscan), display development (Visual C++) data analysis (Statistica, S-Plus, MathCad, Statistica Neural Nets) presentation graphics (Sigmaplot, Canvas), word processing and scheduling (Microsoft Office, Desktop to go) and communication (Eudora) was also purchased.
2) Hardware for permanent and semi-permanent data storage was also needed. Iomega Jaz drives and media were purchased for short-term data storage, including system backups. A Panasonic CD-R (writeable) drive and media were acquired for permanent data storage and dissemination.
3) Five uninterruptible power supplies (Manufactured by Deltec) were purchased to protect all laboratory computers against power surges, brownouts, and to allow systematic shutdown of the computers in case of blackout.
4) Other hardware was purchased to facilitate organization and scheduling, and development of research papers, presentations, and proposals. A 3COM Palm Pilot was purchased to facilitate planning, scheduling, and general lab organization. A Hewlett-Packard flatbed scanner was purchased to scan digital images of real-world textures for simulations and images needed for presentation of research results. A JVC editing VCR and ADS NTSC video converter were purchased to produce videos of our experimental displays for presentations at conferences. An Epson Stylus color inkjet printer was purchased to produce color slides and figures for manuscripts and conference presentations.

II. Research Projects

The proposed use of the equipment was to study the potential of peripheral visual displays for spatial orientation. As proposed, this program of research initially focussed on basic psychophysical studies of the visual mechanisms underlying spatial orientation (the perception of our location in and movement through space) in the context of high workload and wide fields-of-view. Preliminary studies in this line of research have been conducted along two lines: a) perception of the speed of self-motion, or egospeed; and b) perception of the direction of self-motion, or heading. The wide field-of-view display system has only recently become operational, and we are still in the process of integrating the computers controlling the visual simulation with the eye-head tracking system. Hence, our research to date has focussed on issues requiring only a small field-of-view and no measurement of eye and head movements. We expect to have the laboratory fully functional by July 1998.

So far, our studies of egospeed have concentrated on resolving conflicts in the published literature over the use of discontinuity rate and global optical flow rate as determinants of egospeed. There are a number of methodological differences that might explain the conflicting results, e.g., cue validity, frame rate, texture density, environmental layout, and field of view. Our strategy has been to systematically eliminate each possibility to identify the most relevant factors governing perception of egospeed. We began by addressing the effects of frame rate and cue validity on perception of egospeed (Ballard, Roach, & Dyre, In Press). We found that frame rate does not appear to be an important factor mitigating the use of discontinuity rate and flow rate. However, we found that observers are sensitive to—though not necessarily consciously aware of—the validities of these cues as determinants of egospeed and will adapt their perceptual strategy accordingly. Studies currently underway and planned for the near future will examine the effects of texture density, environmental layout, and field of view on perception and *control* of egospeed. For these studies, gaze direction will be monitored in addition to performance measures to gain insight into how observers allocate visual resources during the task.

Research on heading perception has progressed along three lines: a) studies examining differences in heading perception mechanisms during active control and passive viewing, and the interaction of these mechanisms with field of view; b) studies of alternative visual cues for heading, such as velocity symmetry, which are potentially important for peripheral perception and control of heading; and c) theoretical development of a neural network model of human heading perception.

Currently, only the first of these three projects has produced publication (Dyre, Richman, Warren, and Garness, 1998; Richman, Stanfield, and Dyre, In Press). Together, these experiments found that field-of-view is an important factor in determining the visual mechanisms used during active control of heading, but not necessarily during passive viewing. This result has important implications since previous research using passive viewing concluded that field-of-view was unimportant. Our data strongly suggest that an active psychophysical methodology, in which observers control their locomotion, is necessary to more fully understand the visual mechanisms underlying heading perception. Experiments planned for the near future will examine the field-of-view issue in detail using the eye-head tracking system to continuously monitor gaze direction. We will thus be able to dynamically mask areas of the visual field (e.g., only the central 15 degrees, or only peripheral vision) to study the interaction of field of view and active control in a more systematic manner.

Before research examining visual cues for heading control can progress beyond the planning stage, the wide field-of-view display system must be operational. At this date, the software development necessary to make the system fully functional is almost completed. By the end of the summer 1998 term I expect data collection for this program of research to be fully underway. This empirical research project is directly related to the theoretical modeling of human heading perception also in progress. The project will test performance predictions of the statistical moments model (Dyre & Andersen, 1994), implemented as a neural network.

Two research projects not listed in the original proposal have also made use of some of the funded equipment. In collaboration with Dr. Justin Hollands I have been developing a model of bias in judgments of proportions (Hollands & Dyre, 1997). This project required presentation of computationally intensive 3D displays, which were generated on the HP Kayak graphics workstation described above. My graduate assistants and I also collaborated with Dr. Curt Braun on a project examining gaze-patterns during perception of warning symbols. This project provided a perfect opportunity for my graduate assistants to learn to use the eye-tracker in a simplified experimental setting. A paper based on these data is in preparation.

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